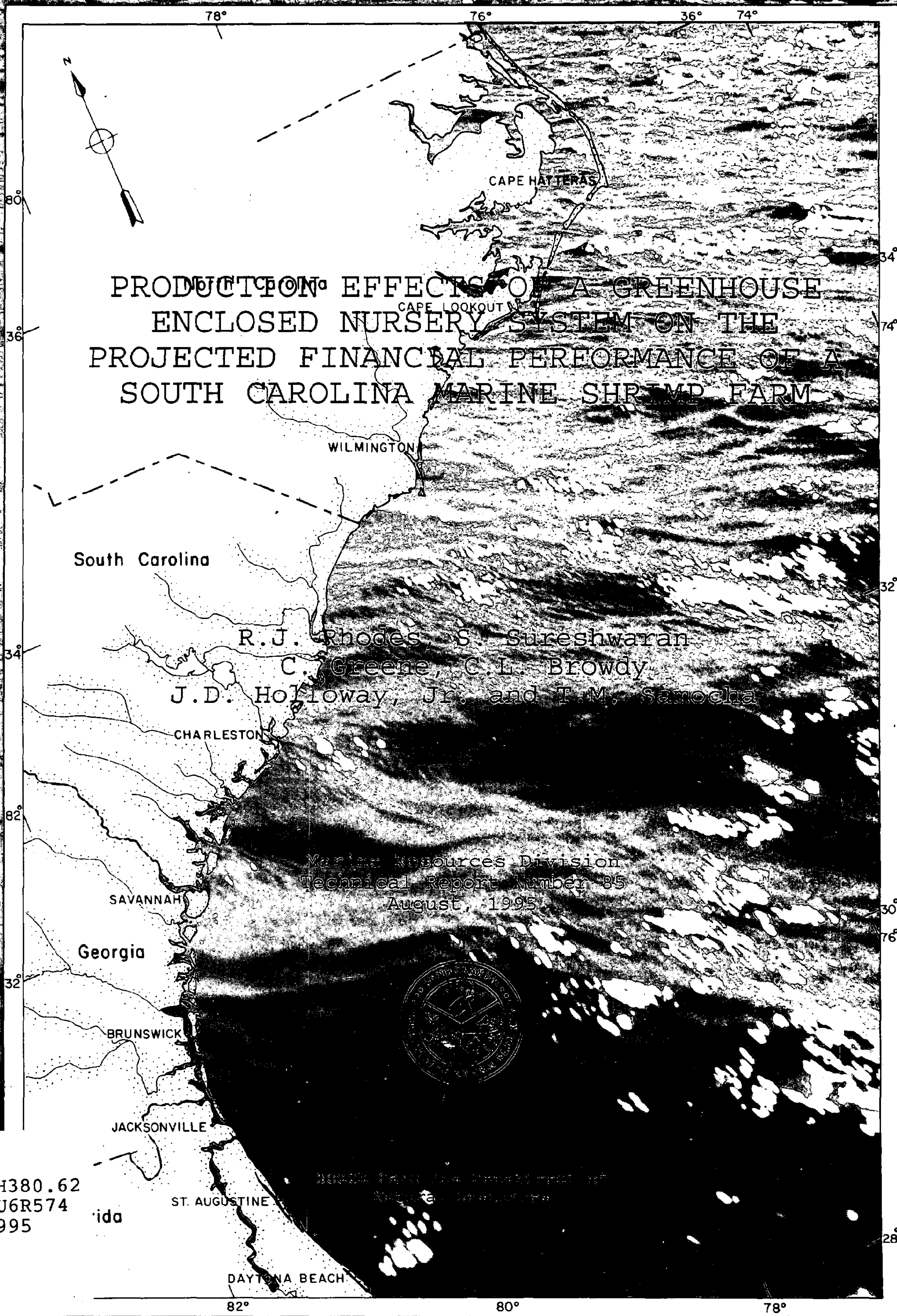

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

SUMMARY

South Carolina's climate restricts marine shrimp growing to one season of five to seven months, which is only long enough to produce one crop per year. This is considerably less than in the Latin American and Southeast Asian countries where two or more crops are grown each year. For South Carolina shrimp producers to be competitive and recover capital cost, they must maximize production during this limited growing season.

The utilization of greenhouse enclosed nursery raceways may be a viable method of increasing the growing season in South Carolina. Postlarvae (PL) are kept in nursery raceways until they reach the juvenile stage and are then transferred to growout ponds. Experimental research in South Carolina and other states indicates that nursery systems can improve the production (i.e. total quantity of shrimp harvested and average harvest size) of shrimp farms. Consequently, the objective of this analysis is to simulate the comparative financial performance of a growout shrimp farm with and without a nursery system in South Carolina. The hypothetical shrimp farm described in this report includes 24 ponds, each 1 hectare (ha) in size, located on 31 ha of land near a salt water source. The base scenario for growout assumes a stocking density of 80 postlarvae(PL)/m^2, an aggregate survival rate of 70%, shrimp harvested at an average size of 17g, and an ex-pond price of \$4.95/kg. In another scenario, the effects of including a greenhouse enclosed nursery system are evaluated. The nursery system is assumed to only supply about 20% of the farm's PL stocking requirements, and the remaining 80% is directly stocked. Survival rates are assumed to be 80% in the nursery phase and 75% in the growout phase for an overall aggregate survival rate of 60%. Larger shrimps ($\bar{x}$ = 20g) are produced when a nursery is utilized, fetching a price of \$5.10/kg. The effects of alternative prices and survival rates are examined in four other scenarios.

The total initial investment in facilities and equipment to begin a *P. vannamei* growout shrimp farm <u>with</u> a greenhouse enclosed nursery system is \$1.1 million. This represents a \$103,000 increase in investment from a facility which only contains a growout farm. After the second year, when the farm produces at full capacity, the projected net cash flow is \$397,000. This is a \$56,000 per annum increase compared to the base case scenario <u>without</u> a nursery system.

The 10-year projected modified internal rate of return (MIRR) before income taxes for the growout farm with the nursery system, 18.9%, is marginally higher than in the base scenario, 17.9% <u>without</u> the nursery. The projected net present

value (NPV) with the nursery system, $384,000, is also higher than the base scenario, $259,000. The internal rate of return (IRR), NPV and MIRR were sensitive to changes in the base case prices and survival rates. However, in all scenarios discussed in this report, the IRR and MIRR are higher than the assumed 15% risk-adjusted cost of capital.

Given the marginal increase in NPV when partially stocking the growout facility with nursery derived shrimp, it is questionable whether the present nursery system is a viable financial alternative <u>solely</u> based upon increasing aggregate yields and harvest sizes. However, additional financial analyses are needed focusing on possible nursery operation risks, nursery/farm size economies of scale and nursery effects on coping with PL supply risks. Under conditions where PL supplies are limited and/or are of questionable health or fitness, nursery systems may be the only practical way for temperate growers to reduce risks associated with PL stock availability.

INTRODUCTION

In recent years, farmed shrimp production in the United States has increased substantially. In the 1993 season, the United States produced a record crop of farm-raised shrimp, approximately 2,500 metric tons, 25% more than the estimated 2,000 tons in 1992 (Rosenberry, 1993). South Carolina, with one-fifth of the nation's cultured output, is the second largest farmed shrimp producing state.

Commercial cultivation of marine shrimp in earthen ponds or impoundments in South Carolina is climatically restricted to producing one crop per year, over a five to seven month period. This is considerably less than in the Latin American and Southeast Asian countries where two or more crops are commonly grown each year. For shrimp producers in temperate regions to be profitable, they generally must cost effectively maximize production during this limited growing season, perhaps by incorporating advanced techniques into farming operations. In addition, the short window of opportunity for stocking coupled with limited supplies of healthy postlarvae (PL) have forced commercial growers to stock late in the season, reduce stocking densities and/or not stock any or all ponds in a given season. For example, in 1989, several SC farms had to reduce planned stocking densities and/or not stock all their ponds due to an apparent seasonal shortage of quality PL (Rhodes et al., 1992).

The utilization of greenhouse enclosed nursery raceways may be a viable method of expanding the stocking window while increasing the growing season in South Carolina. PL are kept in nursery raceways until they are transferred to growout ponds. Advantages of nursery raceways compared to direct stocking of PL include better control of predators, more accurate production projections, less feed waste (feed is generally the largest operating cost of a shrimp farm's budget), and increased profitability (Samocha et al., 1993A). In essence, a greenhouse enclosed nursery facility may provide the following three advantages: (1) The growout season may be extended, allowing for the production of larger shrimps or possibly two crops per year. (2) Proper stocking of juveniles following a nursery phase should increase survival rates and improve consistency in estimating pond biomass during the growout phase. This can result in improved pond and feed management. (3) The nursery could allow producers more flexibility in stocking schedules by taking delivery of PL earlier in the year (e.g. March and/or April) and "stockpiling" the PL in their nursery facility.

Yet, there are potential disadvantages of implementing this type of intensive nursery system. Before water temperatures reach 20°C to 25°C, sea water temperature must be increased by some means in the nursery system for operation. An intensive greenhouse system is also more expensive to build than regular outdoor nursery ponds and a greater level of worker skill is needed to maintain and operate the system. In addition, high stocking densities in raceways can increase the probability of massive mortalities due to operating risks (e.g. equipment failures, etc.).

Research results on the effects of nursery raceway systems are contradictory. Samocha and Lawrence (1992) concluded that an intensive nursery raceway system generally results in larger shrimp and thus, greater market price and higher revenue. In contrast, Juan et al.(1988) concluded that direct stocking of growout ponds with PL and producing one crop per year in southern Texas is more profitable than using intensive raceway systems and producing two crops per year. The extrapolation of results to South Carolina is questionable given that Texas producers generally have a longer growout season. Consequently, given the advantages and disadvantages of greenhouse nursery systems, the objective of this research is to compare the financial viability of a growout shrimp farm with and without a nursery system in South Carolina.

METHODS AND DATA

Growout Operation

Facility design and equipment, production assumptions and major financial assumptions for the growout operation are discussed thoroughly in Sureshwaran et al. (1994). A brief review is provided below.

The facility consists of 24 ponds [See Figure 1 in Sureshwaran et al.(1994)], each of 1 hectare in size, constructed on a 31 hectare farm that is leased near a saltwater source. Specific pathogen free (SPF) *P. vannamei* are used in this study (Wyban et al., 1992, 1993). It has been found that use of SPF *P. vannamei* has increased survival rates, feed efficiency, production and profitability for the shrimp industry (Carpenter and Brock, 1992, Jaenike et al., 1992).

The length of the growout cycle is 5.0 months. Aggregate survival is assumed as 75%. The risks associated with growing shrimp include nutritional and environmental factors, such as poor quality feed, poor water quality, pollution, and low dissolved oxygen. The risks of growing shrimp are not examined in this study. In addition, the study does not account for natural disasters such as drought, hurricanes, etc.

A feed conversion rate of 2.0:1 is used. The harvest weight is estimated using a density dependent growth model (Sureshwaran et al., 1994). A before-tax discount rate of 15% and a planning horizon of 10 years is assumed. Initial investment starts in year 0, first year output is 50% of maximum capacity, second year output is 75% of maximum capacity and third year overall production is at 100% of capacity.

It is assumed that all shrimp are produced for normal market sales, i.e., no live shrimp sales. These shrimp are sold head-on (whole) to individuals, restaurant distributors, and wholesalers. Prices for the base scenarios are similar to those that prevailed in South Carolina during 1993 for the estimated harvest weights. Post-harvesting losses were set at 2% of total harvest.

Nursery System

Facility Design And Equipment

The plan and operation of the nursery system discussed in Samocha and Lawrence(1992) provide the basis for the present design. In general, the hypothetical nursery system consists of 4 concrete raceway structures each 10 feet wide X 108 feet long in size, constructed on land that is available as part of the growout operation (Figures 1 and 2). A 2-foot walkway separates each raceway. Raceways are built to alleviate complications of drainage at harvest. The forms are fabricated from fiber mesh concrete. Each raceway has a center partition and a water depth of 4 feet. The bottom slope is 0.5 percent with a 5-foot deep sump at one end. The sump aids in the removal of waste from the raceways. A 58 feet wide X 144 feet high gutter connected greenhouse is constructed to enclose raceways.

An average water exchange rate of 30% per day is employed with a maximum of 50% per day. To pump the water into raceways, 4 pumps with flow ratings of 240 gallons per minute and 5 horsepower (hp) motors are used. The pumps allow for oxygen injection, water circulation, and filtration. One sand filter per raceway is required. Each will be equipped with top mounted multi-port valves and will have the capacity of about 20 m^3/h for each raceway. The sand filter is responsible for filtering incoming sea water as well as the raceway water. It is assumed that three phase electrical wiring is used for pumps. The multi-port valve directs water from pump to sand filter then back to the raceway or to the sump for drainage. An oxygen injection system is used for aeration when needed. The system includes a liquid oxygen storage tank, pressure regulator, distribution system pipes and valves, oxygen filters, oxygen flow meters, and oxygen diffusers.

Equipment required for the nursery system are: (1) a hauling trailer for transporting juveniles to growout ponds; (2) 20 automatic feeders; (3) harvesting equipment; (4) alarm system, and (5) an *Artemia* hatching system. It is assumed that all personnel from the grow-out operation are employed for nursery needs. Equipment required for the nursery system already available in the grow-out farm are: (1) office trailer; (2) trucks; and (3) harvest and lab equipment. The straight-line depreciation method is used for the growout and nursery facility. It is also assumed that this hypothetical facility is not funded by debt capital, i.e., no loans. The annual financial projections for this facility are generated using a spreadsheet template prepared by Applied Analysis, Inc. (AAI), (Leung and Rowland, 1989). A modified internal rate of return (MIRR) formula was added to the AAI original template. MIRR is defined as the interest rate applied to negative project balances that equates the final project balance to zero. When compared to the internal rate of return (IRR), MIRR is a better measure of profitability because the MIRR assumes that net cash flows from all investment projects are reinvested at the cost of capital while the IRR assumes that cash flows are reinvested at the project's own IRR (Brigham and Gapenski, 1990).

Production Assumptions

Raceways will be stocked at 12,500 PL/m^2 in early March. All PL are stocked in one day and harvested three weeks later. The PL in the nursery raceway system are assumed to have a survival rate of 80% and a feed conversion rate of 2.0:1. The feeding rates for dry feed vary from 10% in the first week, 12.5% in the second week and 15% in the third week. The PL are fed dry feed from stocking according to consumption, and feed particle size is adjusted according to animal size. *Artemia* nauplii and frozen adult *Artemia* are offered as a supplement to dry feeds.

Shrimp reared from PL that are transferred from the nursery system into growout ponds are assumed to have a higher survival rate of 75% during the growout phase and reach a larger harvest size of 20g, when compared with direct stocking. The nursery system will supply about 20% of the farm's stocking requirements, and the remaining 80% is direct stocked.

Major Financial And Operating Assumptions

The major financial and operating assumptions for the nursery system are the following: (1) price of PL including transportation is \$10.00 per 1,000; and (2) the cost of *Artemia*, including the hatchery system, is \$2,200 for a 3-week period. Other financial assumptions are similar to the growout farm: (1) a before-tax discount rate set at 15%; (2) planning horizon is 10 years; and (3) all values are measured in 1994 dollars.

Alternative Scenarios

The following six scenarios are developed to compare the effects of alternative survival rates and ex-pond prices:

Scenario S1A: Growout Only - Stocking density of 80 PL/m^2, direct stocking growout survival rate of 70%, harvest price of \$4.95/kg for 17g shrimp.

Scenario S1B: Growout with Nursery - Stocking density of 80 PL/m^2, the nursery system supplies 20% of the farm's stocking requirements, nursery survival is 80% and growout survival rate of shrimp from nursery is 75%, harvest price of shrimp from nursery is \$5.10/kg for 20g shrimp, growth, survival and harvest price of direct stocked PL are the same as scenario S1A.

Scenario S2A: Growout Only - Same as S1A except harvest price <u>decreased</u> to \$4.70/kg.

Scenario S2B: Growout with Nursery - Same as S1B except harvest price of directly stocked PL is \$4.70/kg and \$4.90/kg for shrimp from nursery.

Scenario S3B: Growout with Nursery - Same as S1B except survival rate during the nursery phase is <u>decreased</u> to 65%.

Scenario S4B: Growout with Nursery - Same as S1B except survival rate during the nursery phase is <u>increased</u> to 85%.

Scenarios S1A and S1B are "base case" scenarios for growout without and with a nursery system.

RESULTS

A base case scenario for the *P. vannamei* growout operation <u>only</u> (Scenario S1A) serves as a reference point for evaluating the impacts of alternative scenarios. Scenario S1B is the base case for a farm with a greenhouse enclosed nursery system. The scenarios with the growout operation only (S2A) and the combined growout and nursery operation (S2B) evaluate the impacts of decreases in ex-pond prices. Scenarios S3B and S4B consider a 10% decrease and increase, respectively, in the nursery survival rates.

The projected initial investment in facilities and equipment is approximately $998,000 for the 24-ha *P. vannamei* growout shrimp farm without a nursery system (Table 1). Equipment comprises about 49% of this cost. Land clearing and construction costs account for approximately 48%. The operating cost in year 1 is $0.38 million. Therefore, the growout shrimp farm without a nursery system requires a total initial investment of $1.38 million before any revenue from sales is received.

A simple, ***pro forma*** annual income statement for operating years three through ten was generated for the *P. vannamei* growout shrimp farm without a nursery system (Table 2). Projected annual sales are about $1.11 million at full capacity, and total cash operating cost is $0.77 million. Feed and PL accounted for the largest percentage of operating cost, 33% and 25%, respectively (Table 2). Energy accounts for 10% of the operating cost.

The ten-year (before income taxes) internal rate of return (IRR) and net present value (NPV) were projected. The ten-year IRR is 21.5% (Table 2), which is greater than the discount rate of 15%. NPV in ten years is $259,000. The modified internal rate of return (MIRR) in ten years is projected to be 17.9% (Table 2).

The estimated additional investment in facilities and equipment necessary to construct a greenhouse enclosed nursery system on an existing shrimp growout facility is about $103,000 (Table 3). The total estimated initial investment in facilities and equipment to construct a growout shrimp farm with a greenhouse enclosed nursery system is about $1.1 million. The operating cost in year 1 is $0.39 million. Therefore, the growout shrimp farm with a nursery system requires a total initial investment of nearly $1.5 million before any revenue from sales is received.

A simple, *pro forma* annual income statement for operating years three through ten was generated for this shrimp farm with a nursery system (Table 4). Projected annual sales are $1.18 million at full capacity, and total cash operating cost is $0.78 million. Again, feed and PL accounted for the largest percentage of operating costs, 33% and 26%, respectively.

Table 1. Summary of facility and equipment costs for a hypothetical 24-ha (water area) *Penaeus vannamei* shrimp farm <u>without</u> a nursery system in South Carolina, 1994.

Item	Cost	Percent[1]	Useful years
DEVELOPMENT COST			
Project Report	$10,000		20
Project Manager	20,000		
Subtotal	$30,000	3.0%	
LAND CLEARING AND FACILITIES[2]			
Land Clearing, 31ha	$85,250		20
Pond Construction	180,000		10
Seawater Pumps, 3	26,955		10
Electrical System	20,016		10
Discharge and Intake System	96,000		10
Buildings	54,000		20
Survey, Permits & Design	15,000	47.8%	10
Subtotal	$477,221		
EQUIPMENT			
Harvest Equipment	$15,000		10
Feed Storage Bins	36,000		10
Paddlewheels	240,000		5
Trucks/tractors	62,500		20
Feeding System	40,500		5
Power Equipment	11,000		10
Pumps	82,800		5
Other	15,000		
Subtotal	$490,300	49.2%	
TOTAL COSTS	$997,521	100.0%	

Total Cost Per Water Area:	$41,563/ha

[1]Percent of total cost.

[2]It is assumed that the land would be leased.

Table 2. Projected annual income statement for operating years three through ten and discounted cash flow analysis for a hypothetical 24-ha *Penaeus vannamei* shrimp farm without a nursery system in South Carolina.

Item	Value or Cost (**in thousands**)	Percent[1]
Projected Annual Sales (223,910 kilograms at $4.95/kg)	$ 1,108	
Projected Annual Expenses		
Postlarvae	$192	25%
Feed	252	33
Energy	80	10
Land lease	60	8
Labor	59	8
Salaried Personnel	83	11
Contingency	8	1
Other	33	4
TOTAL OPERATING COST:	$767	100%
Operating Cost Per Kg:	$3.43/kg	
Projected Depreciation:	$129	
Total Operating Costs with Depreciation:	$897	
Projected Net Income Before Taxes:	$211	
Net Cash Flow (Sales Minus Total Operating Cost)	$341	
Net Annual Cash Flow Per Kg:	$1.52/kg	

DISCOUNTED CASH FLOW ANALYSIS:	10 years
Net Present Value (dollars 000's) at 15%:	$259
Internal Rate of Return:	21.53%
Modified Internal Rate of Return:	17.86%

[1]Percent of total cost.

Table 3. Summary of additional facility and equipment costs for a greenhouse enclosed nursery system on a hypothetical *Penaeus vannamei* 24-ha shrimp farm in South Carolina, 1994.

Item	Cost	Percent[1]	Useful years
FACILITIES			
Greenhouse	$41,352		10
Raceway Construction	28,000		15
Pumping	8,300		10
Other	4,916	80.3%	
Subtotal	$82,569		
EQUIPMENT			
Liners	$6,848		10
Feeders, 20	2,000		5
Sand Filters, 4	1,600		10
Transfer Trailer	2,500		10
Pumps	4,140		10
Other Equipment & Materials	3,140		10
Subtotal	20,228	19.7%	
TOTAL COSTS:	$102,796	100.0%	

[1]Percentage of total operating cost.

Energy accounted for 10% of the operating cost. Total annual cash outflow is $0.780 million; the average operating cost is $3.33/kg (Table 4). The weighted, average selling price is $4.99/kg[1].

The projected ten-year MIRR is 18.9% (Table 4), which is greater than the before-tax discount rate of 15%. The projected NPV in ten years is $384,000. The IRR in ten years is projected to be 23.7%. Thus, the inclusion of a greenhouse enclosed nursery system might modestly increase the profitability of a 24-ha shrimp farm in South Carolina.

The profitability of the systems was compared under alternative scenarios (Table 5). As expected, when price decreases, the profitability of shrimp farming decreases. As in Scenario S3B, a decrease in the nursery survival rate to 65% will reduce overall profitability below that of the non-nursery base scenario, S1A. Scenario S4B shows that an increase in the nursery survival rate[2] substantially increases the overall profitability.

DISCUSSION

Relative to the investment in a growout facility, the inclusion of a greenhouse enclosed nursery system required a marginal increase in the initial investment in equipment and facilities. There were also some increases in PL and energy cost components of operating expenses. Labor costs were not increased in this analysis because it was assumed that the same staff would operate both the raceways and the growout operation. This assumption is debatable if much of the farm's staff time is used in the off season for repair and maintenance tasks related to the growout operation.

In the base scenario, growout survival was hypothetically projected to be 75% for ponds stocked with nursery juveniles as compared to 70% for direct stocked ponds. In addition, the projected growout harvest size of nursery shrimp was 20g compared to 17g for directly stocked PL. These projected increases in harvest size and survival rate of the nursery shrimp from the growout ponds resulted in an overall increase in projected harvest biomass and in total annual revenues (sales). Potential management advantages (e.g. improved feed management) associated with stocking of juveniles were not addressed in this study.

Expected production benefits need to be considered relative to additional operating risks associated with nursery systems. For example, transferring commercial quantities of juvenile shrimp from raceway tanks to outdoor earthen ponds during warm weather may cause significant mortality. There are also significant mortality risks associated with the operation of an intensive nursery system. None of these risks were analyzed in this study.

Economies of scale were not considered, therefore the results of this study may be more beneficial to large scale producers than small producers (e.g. less than 10-ha farms). In addition, expanding the

Table 4. Projected annual income statement for operating years three through ten and discounted cash flow analysis for a hypothetical 24-ha *Penaeus vannamei* shrimp farm with a greenhouse enclosed nursery system in South Carolina.

Item	Value or Cost (**in thousands**)	Percent[1]
Projected Annual Sales		
177,000 kilograms at $4.95/kg	$876	
59,000 kilograms at $5.10/kg	301	
Total Sales	$1,177	
Projected Annual Expenses		
Post larvae	$202	26%
Feed	254	33
Energy	80	10
Land lease	60	8
Labor	59	8
Salaried Personnel	83	11
Contingency	8	1
Other	33	4
TOTAL OPERATING COST:	$780	100%
Operating Cost per Kg.:	$3.33/kg.	
Projected Depreciation:	$139	
Total Operating Costs with Depreciation:	$919	
Projected Net Income before Taxes:	$258	
Net Cash Flow: (Sales Minus Total Operating Cost):	$397	
Net Annual Cash Flow per Kg.:	$1.68/kg.	

DISCOUNTED CASH FLOW ANALYSIS:	10 years
Net Present Value (dollars 000's) at 15%:	$384
Internal Rate of Return:	23.65%
Modified Internal Rate of Return:	18.90%

Percentage of total operating cost.

Table 5. Discounted cash flow analysis for the alternative scenarios for a hypothetical *Penaeus vannamei* shrimp farm with and without a nursery system in South Carolina.

Scenarios	NPV ($)	IRR (%)	MIRR (%)
Scenario S1A	$259,000*	21.53*	17.86*
Scenario S1B	$384,000*	23.65*	18.90*
Scenario S2A	$ 45,000	16.19	15.39
Scenario S2B	$170,000	18.96	16.75
Scenario S3B	$258,000	20.91	17.65
Scenario S4B	$511,000	26.30	20.03

* Base scenarios.

Scenario S1A: Growout Only - Stocking density of 80 PL/m^2, direct stocking growout survival rate of 70%, harvest price of $4.95/kg for 17g shrimp.

Scenario S1B: Growout with Nursery - Stocking density of 80 PL/m^2, the nursery system supplies 20% of the farm's stocking requirements, nursery survival is 80% and growout survival rate of shrimp from nursery is 75%, harvest price of shrimp from nursery is $5.10/kg for 20g shrimp, growth, survival and harvest price of direct stocked PL are the same as scenario S1A.

Scenario S2A: Growout Only - Same as S1A except harvest price decreased to $4.70/kg.

Scenario S2B: Growout with Nursery - Same as S1B except harvest price of directly stocked PL is $4.70/kg and $4.90/kg. for shrimp from nursery.

Scenario S3B: Growout with Nursery - Same as S1B except survival rate during the nursery phase is decreased to 65%.

Scenario S4B: Growout with Nursery - Same as S1B except survival rate during the nursery phase is increased to 85%.

NPV = Net present value before taxes.

IRR = Internal rate of return before taxes.

MIRR = Modified internal rate of return before taxes.

Before-tax discount rate is 15%.

scale of the nurse system to supply a major portion of juveniles stocked in the growout ponds was not examined. Also, various opportunity costs were not evaluated (e.g. marketable securities, etc.).

As previously discussed, one of the potential advantages of a nursery system is allowing a producer to stockpile PL before they are needed for stocking growout ponds. Moreover, if supplies of PL become tighter in the future seasons and/or PL health and fitness are not assured, nursery systems may become the only practical way for SC producers to reduce these PL supply risks. The financial "trade-off" between reducing PL supply risks vs. operating risks of stockpiling PL was not examined in this analysis.

CONCLUSIONS

The long term viability of the South Carolina shrimp farming, among other factors, depends on the ability of its producers to incorporate new techniques, particularly those with the potential to improve production during a limited growing season. Some believe that greenhouse enclosed nursery facilities may offer such an opportunity to the producers. Consequently, the comparative financial performance of a growout operation with a greenhouse enclosed nursery system was evaluated in this study. The projected, before taxes MIRR for a hypothetical *P. vannamei* growout shrimp farm with a greenhouse enclosed intensive nursery system was 18.9%, only slightly greater than the estimated 17.9% MIRR for a growout shrimp farm without the nursery system. Given this small increase in profitability when partially stocking a growout facility with nursery derived shrimp, it is questionable whether an enclosed greenhouse nursery system is a viable financial alternative solely based upon increasing aggregate yields and harvest size.

Additional financial analysis on the costs and benefits of shrimp nursery techniques for penaeid shrimp farms working in locations with a limited growing season is needed. Future analyses should focus on possible nursery operation risks, nursery/farm size considerations[3] and nursery effects on coping with PL supply risks.

Figure 1 Schematic Diagram of Raceway System

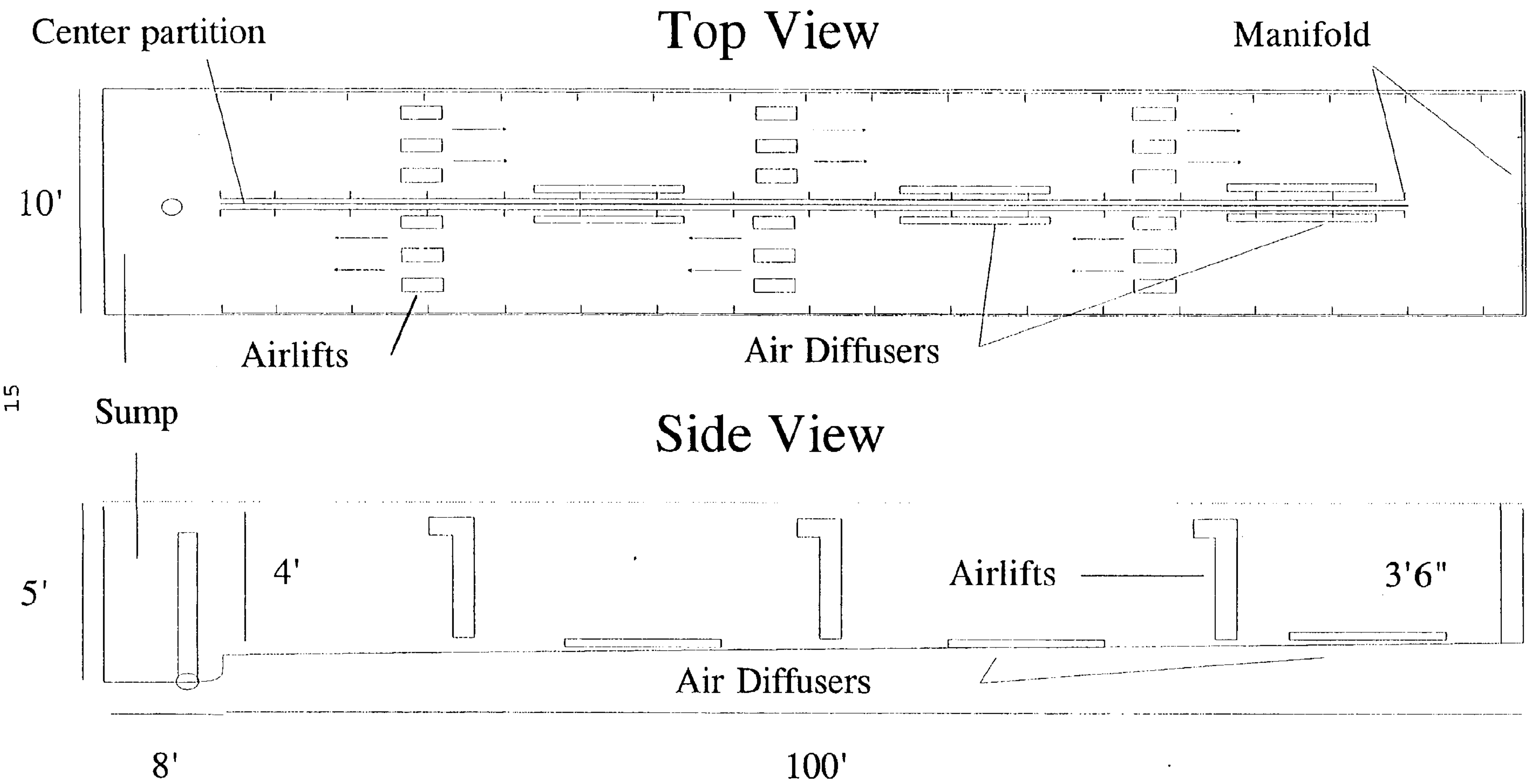
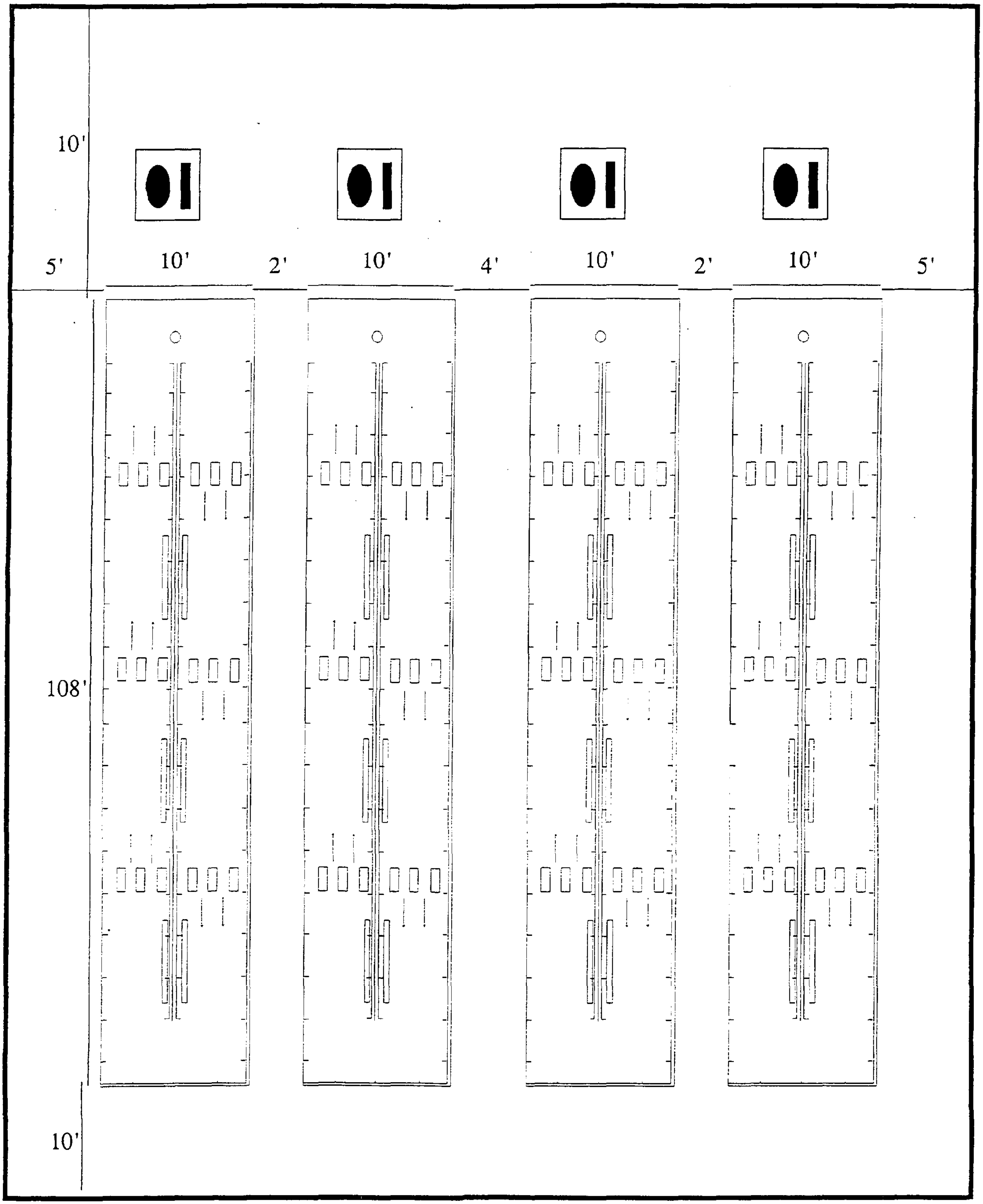


Figure 2 Schematic Diagram of Greenhouse Enclosure



LITERATURE CITED

Brigham, E.F. and L.C. Gapenski. 1990. Intermediate financial management. The Dryden Press, Orlando, FL., 923pp.

Carpenter, N. and J.A. Brock. 1992. Growth and survival of virus infected SPF *P. vannamei* on a shrimp farm in Hawaii. Pages 285-294 In: W. Fulks and K.L. Main (Editors). Diseases of cultured penaeid shrimp in Asia and the United States. Oceanic Institute, Honolulu, HI, USA.

Jaenike, F., K. Gregg, and L. Hamper. Shrimp production in Texas using specific pathogen-free stocks. Pages 295-302 In: W. Fulks and K.L. Main (Editors). Diseases of cultured penaeid shrimp in Asia and the United States. Oceanic Institute Honolulu, HI, USA.

Juan, Y., W.L. Griffin, and A.L. Lawrence. 1988. Production costs of juvenile penaeid shrimp in an intensive greenhouse raceway nursery system. Journal of the World Aquaculture Society, 19:149-160.

Leung, P.S., and L.W. Rowland. 1989. Financial analysis of shrimp production: An electronic spreadsheet model. Computers and Electronics in Agriculture 3:287-304.

Rhodes, R.J., K. McGovern-Hopkins, and C.L. Browdy. 1992. Preliminary Financial feasibility analysis of an independent marine shrimp hatchery located in South Carolina. South Carolina Marine Resources Center, Technical Report Number 80.

Rosenberry, B. 1993. (Editor) World Shrimp Farming: Special Report, Shrimp Farming in the United States. Aquaculture Digest, San Diego, CA, USA.

Samocha, T.M., and A.L. Lawerence. 1992. Shrimp Nursery Systems and Management. Pages 87-105, In: J. Wyban, (Editor). Proceedings of the Special Session on Shrimp Farming. World Aquaculture Society, Baton Rouge, LA, USA.

Samocha, T.M., A.L. Lawrence, and W.A. Bray. 1993A. Design and operation of an intensive nursery for penaeid shrimp. Pages 173-210, In: J.P. McVey and J.R. Moore, (Editors). CRC Handbook of Mariculture, Vol. I., Crustacean Aquaculture. CRC Press, Boca Raton, FL, USA.

Samocha, T.M., A.L. Lawrence, and J.M. Biedenbach. 1993B. The effect of vertical netting and water circulation pattern on growth and survival of *Penaeus vannamei* postlarvae in an intensive raceway system. Journal of Applied Aquaculture 2(1):55-64.

Sureshwaran, S., C. Greene, R.J. Rhodes, C.L. Browdy and A.D. Stokes. 1994. Financial viability of *Penaeus setiferus* versus *Penaeus vannamei* with continuous live harvesting and one final harvest strategies in South Carolina. SC Marine Resources Center, Technical Report Number 84.

Wyban, James A., J.S. Swingle, J.N. Sweeney, and G.A.D. Pruder. 1993. Specific pathogen free *Penaeus vannamei*. Journal of the World Aquaculture Society, 24(1):39-45.

Wyban, James A., J.S. Swingle, J.N. Sweeney, and G.D. Pruder. 1992. Development and commercial performance of high health shrimp using SPF broodstock *Penaeus vannamei*. Pages 254-260, In J. Wyban (Editor). Proceedings of the Special Session on Shrimp Farming. World Aquaculture Society, Baton Rouge, LA, USA.

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1. This is calculated by dividing projected total sales, \$1,177,000, by total harvest, 236,000 kg.

2. Data from earlier experimental studies indicate that survival rates averaging up to 95% are possible in the system (Samocha et al., 1993A).

3. For example, could a nursery system improve the comparative profitability and reduce businesses risks of a small marine shrimp farms (e.g. <12 ha) in South Carolina?